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ABSTRACT

The first part of this bibliography contains annotations of articles on the acquisition of voice onset time (VOT) as the marker of a phonological contrast, that is, the studies concern children who are already developing a phonological system. The most common questions are the following: (1) When children begin to produce initial stops, how are they distributed along the continuum of VOT? (2) When do children begin to consistently produce a VOT distinction? (3) How do children's productions of a VOT distinction compare with those of adult models? Are children making use of VOT in the same way as do adults? (4) How do the VOT values of children's stops change over time? The second section of the bibliography is devoted to studies of speech perception by infants, that is, investigation of infants' abilities to discriminate among various speech sounds. Studies by the following authors are included in the bibliography: Leigh Lisker, Arthur Abramson, Malcolm Preston, Catherine Wolf, Diane Kewley-Port, L. Williams, Claude Simon, Jane Baran, Marsha Z. Laufer, Ray Daniloff, Jeff Elman, Daly Enstrom, Barbara Moslin, L.A. Streeter, T.K. Landauer, Marsha Zlatin, Roy Koenigsknecht, Z.S. Bond, Howard Wilson, J.H.V. Gilbert, Marlys Macken, David Barton, Philip Morse, Patricia Kuhl, Rebecca Eilers, Fred Minifie, Robert Lasky, Ann Syrdal-Lasky, Robert Klein and Lynn Streeter. (AMH)

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VOICE ONSET TIME IN CHILDREN AND INFANTS: AN ANNOTATED BIBLIOGRAPHY [1]

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Introduction

1. Background

Since the publication in 1964 of Lisker & Abramson's cross-language study of voicing contrasts in initial position, the phonetic feature of voice onset time (hereafter, VOT) has been widely recognized as an acoustic dimension sufficient to distinguish stops of different phonemic categories. Briefly, VOT is the interval in time between two phonetic events: the release of a stop in the oral cavity and the onset of vocal fold vibration at the glottis.

VOT can be derived from spectrograms by measuring the distance between the burst of the stop release and the first vertical striation indicating vocal fold vibration. Initiation of glottal vibration, or voicing, before the release of a stop produces a prevoiced stop (one with voicing lead); voicing beginning at roughly the same time as the stop release results in an unvoiced and unaspirated stop (short voicing lag); finally, onset of voicing considerably after release of the stop results in long voicing lag which is normally accompanied by aspiration.

Because of the importance of Lisker & Abramson's 1964 article in demonstrating the role of VOT as a differentiator of stop categories, the article is included in this bibliography. It is the only one to be annotated which does not deal directly with children or infants.

With regard to perception of the voicing distinction, it is accepted that a number of variables in the speech signal serve as perceptual cues for marking the contrast. What is controversial at the moment, however, is the relative salience of the various cues in signaling the distinction. Recent work by Stevens & Klatt (1974), for example, emphasizes the importance of the presence vs.absence of the first formant transition: for stops with short voicing lag, there is a rapid spectral change in the first formant following plosive release, whereas for stops with long voicing lag, the spectral change is already completed by the time voicing begins. This delay in the onset of the first formant in aspirated stops is also known as "first formant (F1) cutback." The question of the role of various acoustic cues for perception is especially relevant to studies on perception of the voicing contrast by infants and is also discussed in the paper by Simon.

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2. VOT in children

Despite the controversy over the role of VOT in perception, there is no doubt as to its importance as an effective acoustic cue for separating stop categories in many different languages. For this reason, and also because of the relative ease in obtaining data on this variable, VOT is especially useful as a measure of the voicing distinction in studying the development of this contrast in children.

The first part of this bibliography contains annotations of articles on the acquisition of VOT as the marker of a phonological contrast, i.e. the studies concern children who are already developing a phonological system. Of these articles, most are on production (the exceptions being the papers by Simon and Wolf; Zlatin & Koenigsknecht also include a discussion of perception data). The most common questions are the following: 1) When children begin to produce initial stops, how are they distributed along the continuum of VOT? 2) When do children begin to consistently produce a VOT distinction? 3) How do children's productions of a VOT distinction compare with those of adult models? Are children making use of VOT in the same way as do adults? 4) How do the VOT values of children's stops change over time? [2]

Results of these various studies are in fairly good agreement: 1) The first stops produced by children generally fall in the short lag range (Preston, Kewley-Port & Preston, Moslin, Macken & Barton); 2) There is variation among children as to when they begin producing a distinction between short lag and long lag stops, the youngest being the age of 1;4 (Moslin) and the oldest being above 2;0 (Macken & Barton). Most studies, it seems, report the distinction to be acquired by the age of two years; 3) Once children produce a phonological contrast between short lag and long lag stops, the range of VOT values for long lag stops is much wider than for short lag stops and is also greater than the range for aspirated stops exhibited by adult speakers (Zlatin & Koenigsknecht; Gilbert).

The most frequently posited explanation for these results is the hypothesis that constraints on the child's physiological capacity account for aspirated stops developing later than unaspirated ones: articulatory gestures for long lag stops are more complex due to the need for more precise timing between release of the stop and onset of voicing; production of short lag stops is presumably simpler since both these phonetic events occur at roughly the same point in time. This hypothesis is a plausible one, but it is only speculative at the current state of knowledge.

The literature suffers, however, from a lack of production data on VOT development in monolingual children whose languages have VOT values different from those of English. Some results are available for Lebanese Arabic (Preston) which distinguishes long lead and short lag stops, and Simon's paper reports perception data on French children whose language makes a similar distinction. Of even greater interest would be studies with children acquiring a language like Thai, with a three-way distinction, or Hindi, which

makes use of both VOT and different modes of phonation (Ladefoged 1971:7-8) for distinguishing all of its initial stops.

Some data are available, on the other hand, on the effects of knowing two languages, and annotations for three of these studies have been included in the first section. All three studies deal with English, and, for the second language, two of them concern Spanish (Williams; Elman) and the third one Kikuyu (Streeter & Landauer), both of which make use of a contrast between stops with voicing lead and ones with short lag. Finally, there is a report on data from language-delayed children (Bond & Wilson).

3. Categorical perception in infants

The second section of the bibliography is devoted to studies of speech perception by infants, i.e. investigation of infants' abilities to discriminate among various speech sounds. The studies are included for annotation since they deal mainly with the discrimination of sounds which differ in VOT value. (The first two articles, by Morse and Kuhl, do not present new data but rather review the literature and the main issues in the field of categorical perception in both infants and animals.)

Research conducted by Eimas et al. and published first in 1971 has produced results that have been taken as evidence for infants' ability to perceive different speech sounds categorically, i.e. infants cannot distinguish between two stops whose VOT values both fall within the boundaries of a single phoneme category, but they can detect a difference between two stops whose VOT values fall on either side of a phoneme boundary. For example, stops with 0 and +20 ms. VOT are not discriminated, whereas stops with +20 and +40 ms. VOT can be.

These findings have raised questions about infants' innate ability to perceive sound distinctions. Research has gone even further, into the perception of both speech and non-speech stimuli by animals (mainly monkeys and chinchillas), and both Morse and Kuhl suggest in their papers that the discrimination abilities of infants may have their origin in the mammalian auditory system which is predisposed to categorical perception.

A major problem of the research in this field, however, has to do with the different methodologies used to test infant perception (the advantages and disadvantages of the various methods are clearly discussed in the Morse paper) and the interpretations given to different results.

As an example of this, Lasky et al. conclude from their study that infants have an innate ability to discriminate two stops categorically whose boundary lies somewhere between -60 and -20 ms. VOT, i.e. between a prevoiced stop and a stop whose VOT is almost simultaneous with the release. Streeter, on the other hand, speculates that discrimination of prevoiced vs. short lag stops is not innate but dependent upon prior linguistic exposure. These conclusions are clearly in conflict, and, in addition, one notes that both the methodological paradigm and the VOT

values of the synthetic stimuli were different in both experiments.

Another problem has to do with the controversy, discussed earlier, over the role of VOT in perception. If it is not exactly clear what cues are the most salient for adults in perceiving the voicing contrast, we are even less certain in knowing what cues infants are responding to. This question is raised especially by the Eilers & Minifie study on fricative discrimination which suggests the importance of the presence vs. absence of F1 cutback in perception of the voicing distinction.

Clearly, the current state of our knowledge does not allow us to interpret with any degree of certainty the results derived from infant perception experiments.

4. The annotations

As indicated above, the bibliography is divided into two major sections: the first contains an annotation of Lisker & Abramson's 1964 article on VOT, and the remaining annotations are of studies dealing with children; the second part is concerned with studies on categorical perception in infants.

The annotations are meant primarily to be descriptive, and any evaluative comments are placed in parentheses and initialed. The entries within each of the two sections are listed in chronological order, and they are written so as to be independent of each other; thus, each annotation contains its own list of references. Although many of the studies have been published, a few unpublished papers have also been included in order to give the reader a wider view of the work that has been done in the field.

Footnotes

1. This bibliography was written for the Stanford University Child Phonology Project, supported by National Science Foundation Grant #BNS76-08968 to Charles A. Ferguson and Dorothy A. Huntington of the Departments of Linguistics and Hearing & Speech Sciences. The author is grateful for their support and acknowledges the help of Deborah Ohsiek, who wrote annotations for the papers by Zlatin & Koenigsknecht, Williams, and Eilers & Minifie. Thanks also go to other members of the project staff, namely Marlys Macken, David Barton, and John Kingston.

2. The paper by Enstrom is the only one which deals with infants and not children. It has been included in this section because the questions it raises are the same as those raised in studies on children.

The following list contains both the work which has been cited above and also references to further studies.

Lisker, Leigh & Arthur S. Abramson. 1964. "Stop categorization and voice onset time." In Proc. of 5th Int. Congress of Phonetic Sciences, Münster. Pp. 389-391.

Abramson, Arthur S. & Leigh Lisker. 1965. "Voice onset time in stop consonants: acoustic analysis and synthesis." In Proc. of 5th Int. Congress of Acoustics (D.E. Commins, ed.) Liege:Imp. G. Thone.

Lisker, Leigh & Arthur S. Abramson. 1967. "Some effects of context on voice onset time in English stops." Language and Speech 10:1-28.

Abramson, Arthur S. & Leigh Lisker. 1970a. "Discriminability along the voicing continuum: cross-language tests." In Proc. of 6th Int. Congress of Phonetic Sciences. Prague: Academia.

Lisker, Leigh & Arthur S. Abramson. 1970b. "The voicing dimensions: some experiments in comparative phonetics." In Proc. of 6th Int. Congress of Phonetic Sciences. Prague: Academia.

Ladefoged. Peter. 1971. Preliminaries to Linguistic Phonetics, University of Chicago Press,

Lisker, Leigh & Arthur S. Abramson. 1971. "Distinctive features and laryngeal control." Language 47:767-785.

Abramson, Arthur S. & Leigh Lisker. 1972. "Voice timing in Korean stops." In Proc. of 7th Int. Congress of Phonetic Sciences, The Hague: Mouton.

Abramson, Arthur S. & Leigh Lisker. 1973. "Voice timing perception in Spanish word-initial stops." Journal of Phonetics 1:1-8.

Zlatin, Marsha A. 1974. "Voicing contrast: perceptual and productive voice onset time characteristics of adults." Journal of the Acoustical Society of America 56:981-994.

Stevens, K.N. & D.H. Klatt. 1974. "The role of formant transitions in the voiced-voiceless distinction for stops." Journal of the Acoustical Society of America 55:653-659.

Lisker, Leigh. 1975. "Is it VOT or ε first-formant transition detector?" Journal of the Acoustical Society of America 57 (6, Part II) 1547-1551.

Klatt, D.H. 1975. "Voice onset time, frication, and aspiration in word-initial consonant clusters." Journal of Speech and Hearing Research 18:686-706.

Williams, Lee. 1977. "The voicing contrast in Spanish." Journal of Phonetics 5:169-184.

Part I: Voice onset time and voice onset time in children

Lisker, Leigh & Arthur S. Abramson. 1964. "A cross-language study of voicing in initial stops: acoustical measurements." Word 20:384-422.

This is a pioneering study (and the most commonly cited of Lisker & Abramson's work) in which the authors demonstrate how a single phonetic dimension, voice onset time (VOT), serves to mark phonemic contrasts among stop categories in a large number of languages. VOT is defined as the time interval "between the release of the stop and the onset of glottal vibration, that is, voicing," (p. 389). The three most common conditions of VOT in the world's languages are, first, the onset of glottal vibration before release of the stop (voicing lead), second, the onset of vibration at about the same time as stop release or shortly after (short voicing lag), and, third, the onset of vibration considerably after release of the stop (long voicing lag, frequently accompanied by aspiration).

The authors limited the study to singleton stops in initial prevocalic position and made a spectrographic analysis of stops produced by adult speakers of eleven languages. Some of these languages contrast two categories of stops: Spanish and Hungarian, for example, distinguish between prevoiced stops, i.e. ones with voicing lead, and stops with short voicing lag, while English and Cantonese, on the other hand, have a contrast between stops with short voicing lag and long voicing lag. Other languages, such as Thai, distinguish three categories of stops, while Hindi and Marathi exhibit a four-way contrast (prevoicing, short lag, long lag, and the so-called "voiced aspirates.")

Data are provided from each language for stops in isolated words as well as in connected speech. For Hindi and Marathi, with four-way distinctions, VOT fails to separate all of the stop categories (the prevoiced stops cannot be distinguished from the "voiced aspirates.") For the remaining languages, however, it is demonstrated that stop phonemes can be distinguished solely along the dimension of VOT. In addition, it was found for speakers of all the languages that VOT values are conditioned in part by place of articulation: velars exhibit longer de-

lay in voicing than other stops.

The authors mention the fact that linguistic descriptions posit different phonetic features as distinguishing stop categories: some languages are said to contrast voiced from voiceless stops, whereas others are described as having aspirated vs. unaspirated stops. From the results of their spectrographic measurements, the authors conclude that these features are not independent but rather are "consequences of a single underlying variable," (p. 422), namely VOT.

Preston, Malcolm S. 1971. "Some comments on the developmental aspects voicing in stop consonants." In Horton, D.L. & J. Jenkins (eds.) Perception of Language. Columbus: Merrill. 236-246.

The author addresses himself to the following questions: 1) When a child begins to produce a large number of stops in initial position, how will they be distributed along the continuum of voice onset time (VOT)? 2) Will language environments with different VOT values produce different VOT distributions in the pre-linguistic vocalizations of children raised in those different environments? 3) If children's early vocalizations do not display distributions of VOT values corresponding to those of the adult language, when and how do children begin to match the adult model?

To answer these questions, longitudinal data in the form of spontaneous production were collected from several monolingual children speaking American English, which distinguishes short lag and long lag stops, and from children acquiring Lebanese Arabic, which distinguishes long lead and short lag stops. Data are presented from four American and three Lebanese children, all between 50 and 57 weeks of age. The results show a unimodal distribution of stops along the continuum of VOT which peaks in the 0 to +30 ms. range. In addition, longitudinal data of one of the American children between 44 and 96 weeks of age indicate an increase in the number of long lag stops as age increases. The author concludes that the capability of producing the voiced-voiceless distinction is established between one and two years of age, and it is suggested that future research be directed toward studying the acquisition of VOT as a perceptually relevant cue.

(One might draw the distinction here between productive capabilities, i.e. the child's ability to make the voicing contrast either occasionally or in some non-adultlike fashion, vs. the child's producing the contrast consistently and correctly from the viewpoint of the adult model. This distinction is crucial to an understanding of what we mean when we say that the child is "acquiring" a contrast.)hc

Wolf, Catherine G. 1973. "The perception of stop consonants by children." Journal of Experimental Child Psychology 16:318-331.

The purpose of the study was to obtain data on the perception of voice onset time (VOT) in American English by kindergarten and second-grade school children which could be related to existing data on VOT perception by infants and adults.

Two quite similar experiments were conducted. In the first, eight kindergarten children (mean age 5;4) and eight second-graders (mean age 7;5) were asked to perform identification and discrimination tasks in which they were presented with synthetically-produced tokens of the syllable /ba/ and /pa/, whose VOT values ranged in 10 ms. steps from -10 ms. to +70 ms. In the identification task, the children were requested to say whether the stimulus was /ba/ or /pa/, and in the discrimination task, they were presented with two stimuli and asked to say whether they were the "same" or "not the same."

In the second experiment, subjects were seven kindergarten children (mean age 5;4) and ten second-graders (mean age 7;6), who were asked to perform the same tasks as in the first experiment except that the stimuli were synthetic tokens of /da/ and /ta/. In addition, there was a third group of subjects consisting of nine second-graders (mean age 7;5) who were given the discrimination task before the identification task. This was to control for the possibility that task order would effect the results.

In both experiments, the children exhibited categorical perception very similar to that reported for adults and infants, i.e. the phoneme boundaries fell at roughly +25 ms. for /b/ vs. /p/, and at approximately +40 ms. for /d/ vs. /t/. In the discrimination tasks, it was found that discrimination of two stimuli was poor at the extremes of the VOT continuum, whereas it was very good for stimuli in the region of the phoneme boundary. Furthermore, no differences were found between the two age groups, and order of task administration was not found to have an effect on the results.

These results are fairly similar to those obtained from infants and adults, and the author speculates that the characteristics of VOT perception are biologically determined, and posits the existence of linguistic feature detectors that are maximally sensitive to differences at specific regions of the VOT continuum.

Kewley-Port, Diane & Malcolm S. Preston. 1974. "Early apical stop production: a voice onset time analysis." Journal of Phonetics 2: 195-210.

The authors use voice onset time (VOT) as a measure of stop con-

sonant production in investigating changes in the development of stops in children acquiring American English.

Longitudinal case studies were conducted with three children (2 girls and 1 boy) whose ages, during the study, were approximately 0;10 to 2;0, 1;0 to 2;5, and 0;8 to 1;10. Tape-recording sessions were made in a sound-treated booth and were taken at roughly 3-month intervals. A parent was present at the sessions and tried to elicit vocalizations from the child during a half-hour period.

Wide-band spectrograms were made of selected vocalizations which began with apical stops, and, in a few ambiguous cases, stops were considered to be initial if preceded by at least 50 ms. of silence.

Results show that the VOT values for initial apical stops fall into a single-mode distribution, with the majority of tokens being in the short-voicing lag range. This is in contrast to the adult data reported by Lisker & Abramson (1964) which exhibit a bimodal distribution corresponding to the phonemic contrast between /t/ and /d/. The authors present longitudinal data from each of the three subjects showing an increase in the number of stops with long voicing lag toward the end of the study, but no attempt is made to analyze the distribution of VOT values in the children's speech in terms of adults models, i.e. one does not know whether or not the children produced stops with long voicing lag when saying words with adult /t/.

In conclusion, the authors hypothesize that children learn to produce stops with short voicing lag earlier than those with long voicing lag for physiological reasons: the articulatory gestures for long voicing lag are more complex because they require very precise control of timing between supraglottal and glottal articulators which are innervated separately.

Lisker, Leigh & Arthur S. Abramson. 1964. "A cross-language study of voicing in initial stops: acoustical measurements." Word 20: 384-422.

Preston, Malcolm S. 1971. "Some comments on the developmental aspects of voicing in stop consonants." In Horton, D.L. & J. Jenkins (eds.) Perception of Language. Columbus: Merrill. 236-246.

Williams, L. 1974. "Speech perception and production as a function of exposure to a second language." Doctoral dissertation, Harvard University.

In her thesis, Williams addresses the issue of categorical perception of phonemes along the voice onset time (VOT) continuum, with a major goal of examining the development of category boundaries in second-language

acquisition.

Subjects. Experiment I: 16 adults, 8 monolingual speakers each of Spanish and English; Experiment II: 8 adults, all bilingual speakers of Spanish and English; Experiment III: 72 juveniles, all native speakers of Puerto Rican Spanish, subdivided into two age groups (8-10 years and 14-16 years) and three groups based on amount of exposure to English (0-6 mo., 1½-2 years, and 3-3½ years, in the U.S.).

Procedure. Subjects performed discrimination and labelling tasks with synthetic speech tokens which varied systematically in VOT, and which included appropriate formant transitions. Additionally, spectrograms were made of subjects' own productions of /b/ and /p/ words, pronounced in isolation and in sentences.

Results. Perception tasks: Discrimination peaks (the range of values of VOT, in ms., within which each subject demonstrated greatest success in distinguishing between stimulus pairs) did not always correlate with labelling crossover points (the area on the VOT continuum where each subject demonstrated greatest random error in assigning stimulus items to a phonemic category). Monolingual speakers of English responded to VOT values for the b/p contrast which differed significantly from VOT values selected by monolingual speakers of Spanish, but all monolingual subjects manifested some mismatch between labelling crossover points and discrimination peaks. Bilingual adults did not appear to use a double standard for judging the identity of the speech sounds, but rather adhered to either a Spanish-like or an English-like set of VOT values (regardless of native language) for labelling. The VOT range in which the bilinguals' discrimination abilities were highest were not confined to a sharp peak value as with the monolinguals, but rather encompassed their labelling crossover points with a wide range of values. The children learning English as a second language had labelling crossover points which appeared to shift closer to the English monolingual values as a function of amount of exposure to English, and these crossover points did not match their discrimination peaks.

Production tasks. VOT values for /b/ and /p/ were greater (i.e. had larger negative values for voice lead and larger positive values for voice lag) for words pronounced in isolation than for words in sentences, for both Spanish and English. Spanish and English monolinguals had significantly different values for the b/p contrasts. The bilinguals' VOT value for English /b/ showed more prevoicing than the monolinguals' English /b/. The VOT values of productions by children learning English suggested a merging of Spanish and English voicing characteristics: their English b/p productions were more Spanish-like than the English monolinguals' b/p, and their Spanish b/p productions were more English-like than the Spanish monolinguals' b/p.

The author interprets these results as possible counterevidence to

categorical perception. She also hypothesizes that the decrease in foreign accent in English and the increase in interference to Spanish for these young learners of English is a function of exposure to the second language. She provides sociolinguistic, acquisition-process, and psychoacoustic explanations for these phenomena. She prefers the psychoacoustic explanation for at least two reasons. The first concerns the possibility of the b/p contrast in English being more perceptually salient than the Spanish contrast, due to the use in English of several acoustic features for the presence or absence of voicing, such as aspiration, VOT, first formant cutback, etc. The second reason deals with the possibility of an innate human predisposition to detect 20 ms. lag times between two acoustic events such as noise burst and voicing onset, exactly the location on the VOT scale where all of the second-language learners and most of the bilinguals discriminated a voicing contrast most readily.

Caramazza, A., G.H. Yeni-Komshian, E.B. Zurif, & E. Carbone. 1973. "The acquisition of a new phonological contrast: the case of stop consonants in French-English bilinguals." Journal of the Acoustical Society of America 54:421-428.

Major, Roy C. 1977. "Phonological differentiation of a bilingual child." Ohio State University Working Papers in Linguistics, No. 22. Columbus. 43210. February. Pp. 88-122.

Vogel, Irene. 1975. "One system or two: an analysis of a two-year-old Romanian-English bilingual's phonology." Papers and Reports in Child Language Development 9:43-62.

Williams, Lee. 1977. "The voicing contrast in Spanish." Journal of Phonetics 5:169-184.

Child Phonology Project. 1975. "Acquisition of the voice distinction in initial stops in English, Spanish, and Cantonese." (Research proposal)

This research proposal, being carried out by the Child Phonology Project at Stanford University, approaches the problem of how voicing distinctions in initial stops are acquired from the point of view of children's productions. The following questions are raised: 1) What are the spectral characteristics of children's stop productions? 2) How do these characteristics correlate with and compare to the voiced-voiceless distinction in adult productions? 3) Is voice onset time (VOT) an adequate descriptor of the way in which children acquire the voicing distinctions among initial stops in their mother tongue?

The project studies children of two different age groups: 1) 1;4-1;6 at the beginning of recording, and 2) pre-schoolers, aged 4-6 years.[1] For each age group, subjects are four monolingual children from each of

the following language backgrounds: English, Cantonese (both of which distinguish short from long lag stops) and Spanish (which makes use of the distinction between long lead and short lag stops).

From children in group (2), data are being collected in two half-hour taping sessions, and the subjects in group (1) are being recorded at two-week intervals over a period of about eight months. Both spectrographic and oscilloscope analysis are being made of the stop productions of all the children.

The following hypotheses are being investigated: 1) 1½-2¼ years. When the child begins to develop a phonological system with stable stops in his productions, stops in the short lag range predominate; 2) 4-6 years. The child controls production of the voicing distinction in all positions, but the VOT values are still not identical with those of adult speech.

Macken, Marlys, & David Barton. 1977. "A longitudinal study of the acquisition of the voicing contrast in American-English word-initial stops, as measured by VOT." Paper presented at the Second Annual Boston University Conference on Language Development. Sept. 30-Oct. 1.

1. The original intention was to include babbling data from infants as well. As of September, 1977, however, the data have not been collected.

Simon, Claude. 1975. "The development of some speech patterns in children." To appear in the proceedings of the 8th Int. Congress of Phonetic Sciences, Leeds.

This study addresses itself to children's acquisition of the voiced-voiceless distinction in initial stops in English and French. It is not concerned with acquisition of the phonemic contrast as such but rather with the development of the complex set of acoustic patterns which comprise the adult distinction, i.e. how are different speech patterns used by children of different ages in both the perception and production of a given adult phonological contrast?

A report is made of perception experiments with English- and French-speaking children aged 3, 5, and 14 years. (The number of subjects in each group is not specified.) The purpose of the experiments was to investigate the relative importance of voice onset time (VOT) and the shape of the first formant (F1) onset in the perception of voiced as opposed to voiceless stops by children of these ages. Real-word stimuli were synthesized and presented to the children in random order for labelling.

Results for the English children show a qualitative difference between

the older and the younger children: the older ones need to hear both short lag VOT and F1 transition together in order to label stops as being voiced. For the younger children, on the other hand, either short VOT lag or F1 transition is a sufficient cue for discriminating the distinction.

The French children exhibit a somewhat different pattern of responses: presence or absence of F1 transition is not important for discriminating the distinction. This is not surprising since the French distinction is one between long lead vs. short lag stops, where both kinds of stops have F1 transition following the burst.

In concluding, the author postulates two different Acoustic Pattern Processing mechanisms in children, one whose purpose is to process the speech of the adult, and the other one designed to monitor the child's own output. It is through the interaction of these two processing mechanisms that the child eventually arrives at a system of phonetic features and cues identical to those of the adult.

Stevens, K.N. & D.H. Klatt. 1974. "The role of formant transitions in the voiced-voiceless distinction for stops." Journal of the Acoustical Society of America 55:653-659.

Baran, Jane A., Marsha Zlatin Laufer, & Ray Daniloff. 1976. "Phonological contrastivity in conversation: a comparative study of voice onset time." Paper submitted to the Journal of Phonetics.

The purpose of this study was to investigate the variation in the VOT values of stops produced by adults in three conditions: 1) citation forms, 2) adult-directed conversation, and 3) speech addressed to preverbal children.

Data were collected from three mothers (American English) whose children were participating in a longitudinal study of phonological development. Samples of the three types of speech were recorded in a sound-treated booth, and both wide- and narrow-band spectrograms were made of all prevocalic stops.

A classification system for conversational speech was devised with the aim of categorizing stop tokens according to where voicing occurred with respect to the stop release: e.g. stops with 25 ms. silence before either voicing lead or the burst, stops with continuous voicing throughout the closure and the release, etc.

Results show that the difference in mean VOT values between voiced and voiceless stops is much greater in citation forms than in conversational speech. In addition, no significant differences were found between speech directed to adults and speech directed to children with re-

gard to the VOT values of prevocalic stops, although there were individual differences among the mothers. In other words, the mothers did not appear to be maximizing the voicing contrast for their children.

The authors speculate that this may be due to the fact that the children at this time are all preverbal, and that the voicing contrast will be maximized by the parent once the child begins speaking. The hypothesis, then, is that the onset of "meaningful" speech in the child's development determines the characteristics of the parents' child-directed language.

This finding does therefore not conflict with the report by Moslin (1976), who found a difference in VOT values for stops between speech addressed to adults and speech addressed to children, but whose child subjects were already speaking.

Moslin, Barbara. 1976. "Development of the voiced-voiceless contrast in English stops: a voice onset time analysis of two mother-child dyads." Paper presented at the 7th meeting of the Northeast Linguistic Society.

Elman, Jeff. 1976."The acquisition of voice onset time in bilabial stops by Spanish-English bilingual children: a pilot study." Manuscript, University of Texas.

The goal of this study is to answer the following questions: 1) At what age do Spanish-English bilingual children acquire the voice onset time (VOT) values of both languages for bilabial stops in initial position? 2) How do bilingual children acquire languages with different phonetic values for phonological contrasts? In addition, a useful review of studies on bilingual phonology is included at the beginning of the report, and the end is reserved for some discussion concerning the controversy over the continuity or discontinuity of the acquisition process as the child passes from babbling to a linguistic stage or "true speech."

Subjects for the study were four children ranging in age from 2;7 to 7;10, and one bilingual adult. Data consist of taped speech collected in the subjects' homes during an imitation task and spontaneous production. Results show, first, a general parallel between imitated and spontaneous production in that differentiation of stops in spontaneous forms correlates with more accurate imitations, and, second, a correlation between the children's ages and differentiation both among VOT values and between the two languages. The author draws the tentative conclusion that bilingual children have a single phonemic system up to about 3 years of age, and that a re-organization of their phonology takes place between 3 and 4½ years. Alternative interpretations of the data are offered.

Major, Roy C. 1977. "Phonological differentiation of a bilingual child." Ohio State University Working Papers in Linguistics, No. 22. Columbus, 43210. February, pp. 88-122.

Vogel, Irene. 1975. "One system or two: an analysis of a two-year-old Romanian-English bilingual's phonology." Papers and Reports in Child Language Development 9:43-62.

Enstrom, Daly. 1976. "Infant labial, apical and velar stop consonant productions: a phonetic and spectrographic analysis." Paper presented at the American Speech & Hearing Association National Convention (Houston). To appear in the Journal of Speech and Hearing Research.

This study investigates three questions: 1) What is the percentage of stops in infants' consonant repertoires, and how are stops distributed with respect to place of articulation? 2) What is the voice onset time (VOT) for each category of stops? 3) How do these results compare among infants from very different linguistic backgrounds?

To answer these questions, the author collected babbling data from from 25 nine- to twelve-month-old infants from the Swiss German language environment (Zurich) and examined initial stop consonant production by analyzing VOT spectrographically. (The adult VOT values of Swiss German are not given.) Longitudinal data are reported for the period between 9 and 12 months of age.

Results show the following:

1. Stops comprise about 33% of all consonant productions at 9 months, and this proportion increases to 65% at 12 months. Furthermore, apicals occur with the greatest frequency for each age group, with velars and labials taking second and third places, respectively. The author also notes individual differences in consonant repertoire, with some infants especially favoring one articulatory gesture, either labial, apical, or velar.

2. The majority of stops are produced with VOT values in the short lag range, with velars exhibiting somewhat greater lag than labials and apicals.

3. Swiss German infants exhibit VOT distributions in apical stops very similar to those of infants from Lebanese Arabic and American English environments.

The author concludes by proposing a hypothesis of articulatory difficulty, as do Kewley-Port & Preston (1974), i.e. stops with short voicing lag require fewer articulatory adjustments than stops with either voicing lead or long voicing lag.

Kewley-Port, Diane & Malcolm S. Preston. 1974. "Early apical stop production: a voice onset time analysis." Journal of Phonetics 2: 195-210.

Moslin, Barbara. 1976. "Development of the voiced-voiceless contrast in English stops: a voice onset time analysis of two mother-child dyads." Paper presented at the 7th meeting of the Northeast Linguistic Society.

The author attempts to answer two questions: 1) What are the phonetic characteristics of mothers' speech to children? With regard to voice onset time (VOT) specifically, do mothers exaggerate the distinction between short and long lag stops in speaking to children? 2) What are the phonetic characteristics of children's initial attempts at producing the phonological distinction between short and long lag stops?

Data consist of tape-recorded sessions made biweekly of two mothers (speakers of American English) with their children. The children were 1;3 and 1;4 at the start of the study which lasted six months. Speech of the mothers talking with other adults was also recorded.

The data analyzed were all initial stops produced by the mothers and the children, in both stressed and unstressed syllables, in isolation as well as in sentences. VOT measurements were made on the oscillographic display of a computer.

Results generally indicate that the VOT for mothers' short lag stops is about the same for speech addressed to their children and to other adults. For long lag stops, however, the mothers exhibit greater delay in VOT when speaking to their children.

The author considers the hypothesis that the mothers are not simply exaggerating the distinction to their children, but rather, the mere fact that speech addressed to children is often characterized by a lack of function words and by more slowness and loudness results in greater VOT values for this type of speech than for speech addressed to other adults.

To test this hypothesis, one of the mothers was asked to read aloud a story containing 50 words for which she had exhibited the greatest VOT values when conversing with her child. She was asked to read the story as though telling it to another adult. The VOT values for the stops in this recitation were significantly less than those for stops in which the mother was speaking to her child. The author concludes that the mothers are indeed exaggerating the distinction between short and long lag stops for their children.

Finally, data from the children's production show that short lag

stops were produced before long lag stops; long lag stops, when they appeared in the children's speech, were produced with greater VOT value than those of the mothers; the children were producing the distinction by the age of 1;4.

Baran, Jane A., Marsha Zlatin Laufer, & Ray Daniloff. 1976. "Phonological contrastivity in conversation: a comparative study of voice onset time." Paper submitted to the Journal of Phonetics.

Streeter, L.A. & T.K. Landauer. 1976. "Effects of learning English as a second language on the acquisition of a new phonemic contrast." Journal of the Acoustical Society of America 59:448-451.

The question addressed in this paper is the role of experience in the discrimination of different voice onset time (VOT) distinctions. Kikuyu, a language of Kenya, makes use of a distinction between long lead and short lag stops except at the labial point of articulation where there is only a long lead stop. Authors observed the development of Kikuyu children's discriminations among three VOT categories (long lead, short lag, and long lag), in order to determine whether or not exposure to English effected a change in the discrimination pattern.

Subjects were school children of four different age groups: 7;5, 10, 13, and 15 years, with a range of 21 to 32 children in each group. Only the youngest had no previous exposure to English. Six stimuli, each consisting of a labial stop and vowel, were synthesized with different VOT values, and the experimental procedure involved the presentation of triads in an ABX paradigm. There were three triad types: 1) -30 vs. 0, 2) +10 vs. +40, and 3) +50 vs. +80 ms.

Results indicate that both the children exposed to English and those not exposed to English discriminate between long lead vs. short lag and between short vs. long lag stops. The older group discriminated both distinctions better than the younger group, and the degree of perceptual accuracy between the two groups of subjects was greater for the short vs. long lag contrast than for the long lead vs. short lag contrast.

The authors conclude that the distinction between short and long lag stops is more naturally discriminable than that between long lead and short lag stops, but that experience accounts to a large extent for the performance of the older group of listeners.

Zlatin, Marsha A. & Roy A. Koenigsknecht. 1976. "Development of the voicing contrast: a comparison of voice onset time in stop perception and production." Journal of Speech and Hearing Research 19:93-111.

This study was conducted to examine the development of the production of the voicing contrast in word-initial stop consonants, and to compare these results with perception data from an earlier study (Zlatin & Koenigsknecht, 1975), based on voice onset time (VOT) measurements.

Subjects for the study were 10 two-year-old children, 10 six-year-old children, and 20 adults; all age groups were balanced for sex. Multiple productions of the words bees, peas, bear, pear, dime, time, goat, and coat were recorded from each subject. VOT measurements to the nearest 10 ms. were obtained from spectrograms of the first 30 acceptable productions of each word, and phoneme categories for the speakers' intended productions were established for the three age groups on a VOT continuum.

Extensive statistical analysis of results showed that VOT characteristics within age groups are relatively stable but that the extent of VOT ranges associated with production of voiced and voiceless stops differed as a function of age of the speaker, with younger subjects manifesting wider VOT ranges for voiceless stops. Also, adults consistently produced more voice-lead stops than did the children, and those infrequent children's voice-lead productions were primarily of labial stops. Two- and six-year-olds exhibited more category overlapping (that is, voiced and voiceless cognates did not have a distinct boundary) than did adults, but in general, a majority of productions by subjects in all age groups were concentrated in similar regions of the VOT continuum: /b/ and /d/ VOT = 0 to +20 ms.; /g/ VOT = +10 to +40 ms.; /p/ VOT = +50 to +100 ms.; /t/ and /k/ VOT = +60 to +110 ms.

VOT values for productions by all age groups were compared with data from a perception task reported elsewhere (Zlatin & Koenigsknecht 1975). For adults, six-year-olds, and two-year-olds, respectively, 97.58, 91.42, and 79.8% of their total productions overlapped with the corresponding voicing categories of their identification data. Productions that fell within perceptual categories increased as a function of age particularly for /p/ and /k/.

The authors close with a comparison of their results with those of other researchers in the field, providing a sketch of the evolution of production of the voicing distinction in word-initial stop consonants.

Zlatin, M.A. & R.A. Koenigsknecht. 1975. "Development of the voicing contrast: perception of stop consonants." Journal of Speech and Hearing Research 18:541-553.

Koenigsknecht, Roy A. 1968. "An investigation of the discrimination of certain spectral and temporal acoustic cues for speech sounds in three-year-old children, six-year-old children, and adults." Doctoral dissertation, Northwestern University, Speech Pathology.

Bond, Z.S. & Howard F. Wilson. 1977. "Voicing in the speech of language-delayed children." Paper presented at the 93rd meeting of the Acoustical Society of America.

This study is concerned with acquisition of the voicing contrast in American English by both normal and language-delayed children. Investigation included both voice onset time (VOT) as a marker of the contrast in initial position and vowel duration as a distinctive cue for voicing in final stops, although most of the attention is on VOT. The basic issue is whether or not there is a correlation between language development and proficiency in articulatory control. The measure used for language development is mean length of utterance (MLU); the question then is whether or not children with longer MLU have better phonetic mastery of the voicing contrast than children with a shorter MLU.

Subjects were 10 children, aged 3;0 to 8;7, who were diagnosed as language-delayed and receiving therapy, and 10 children between 1;10 and 3;4 who were acquiring language normally. Although the two groups differed in chronological age, they were matched for equivalence in MLU. Selection of subjects included a screening test in which they were asked to identify natural productions of voiced and voiceless stops. (No details of the experimental procedure are given and no indication of exactly what was being tested.)hc

Both spontaneous and imitation data were collected from each child producing twelve test words which were near-minimal pairs. Spectrograms were then made of the three most intelligible tokens of each word.

Results from both groups show no correlation between MLU and the degree of control over the voicing distinction, i.e. MLU is not useful as a predictor of phonetic accuracy. In addition, it was found that the children with normal language development exhibited longer VOT values for aspirated stops, and that the language-delayed children produced more tokens with voicing lead (for both adult voiced and voiceless stops).

Gilbert, J.H.V. 1977. "A voice onset time analysis of apical stop production in 3-year-olds." Journal of Child Language 4:103-110.

This is a study primarily on phonetic, not phonological, acquisition. Speculating that children learn to produce a given phonological distinc-

tion acceptably while still not controlling mature phonetic values, the author addresses himself to such questions as whether constraints in children's speech are qualitatively different from those of adult speech, and whether speech timing control increases in a gradual quantitative way consistent with age.

Since measurements of voice onset time (VOT) can be made fairly accurately by means of spectrograms, the author selects this aspect of speech in order to compare data from children and adults and attempt to establish a basis for speculating on the course of phonetic acquisition.

Subjects for this cross-sectional study were 4 boys and 2 girls, all acquiring English, and ranging in age from 2;7 to 3;3. Production data were obtained during a single one-hour session with each child in which speech was elicited by both the experimenter and the mother.

Wide-band spectrograms were made of selected tokens of the apical stops /t/ and /d/, taken from spontaneous speech. For the phoneme /d/, results show VOT falling mainly in the range between 0 and +40 ms., corresponding roughly to the adult values for stops with short voicing lag (according to Lisker & Abramson 1964). For /t/, on the other hand, the majority of the children's VOT values fall between +110 and +210 ms., a much wider range than for /d/ and also one whose values are greater than those reported for adult /t/, which fall mainly between +20 and +70 ms., (Lisker & Abramson 1964).

The author states that phonetic acquisition is obviously constrained by limitations on the child's physiological capacity, and, in his conclusion about VOT specifically, says that the child of about 3 years of age has arrived at making a phonological distinction between /t/ and /d/, but that the very wide range of VOT values for /t/ indicates the child's inability to sufficiently control the timing between supraglottal and glottal articulators so as to produce long lag stops with the adult phonetic values.

Lisker, Leigh & Arthur S. Abramson. 1964. "A cross-language study of voicing in initial stops: acoustical measurements." Word 20: 384-422.

Macken, Marlys A. & David Barton. 1977. "A longitudinal study of the acquisition of the voicing contrast in American-English word-initial stops, as measured by VOT." Paper presented at the Second Annual Boston University Conference on Language Development. Sept. 30-Oct. 1.

This study of the acquisition of the American English voicing contrast in initial position aims to investigate the spectral characteristics of young children's stop productions, to determine the age at which

the contrast is acquired, and to document the actual process of acquisition.

Production data were collected over an eight-month period from four children (2 boys, 2 girls) who were roughly 1;6 at the start of the study. Recording sessions took place approximately every two weeks, and the goal of each of these was to elicit at least 15 tokens of each of the six word-initial stops. The data were analyzed by means of spectrograph and an oscilloscope.

It was found that one of the children had the voicing contrast from the beginning, two of them acquired it during the study, and the fourth child still had not developed an adult-like contrast at the end of the study. With regard to the process of acquisition, the longitudinal data fell into three categories: 1) there is no evidence for a voicing contrast, and the children's productions of both adult voiced and voiceless stops fall in the short lag range; 2) there is evidence for the emergence of a voicing contrast in which the mean voice onset time (VOT) values for productions corresponding to adult voiceless stops are significantly greater than the mean VOT values for tokens corresponding to adult voiced stops; both means, however, fall within the boundaries of a single adult phoneme category or very close to the boundary between the two categories; 3) the data are closer to adult values, but at first the means for voiceless stops are considerably greater than those of adults and are eventually shortened toward the adult means.

Individual differences were found with respect to age: three of the children had acquired an adult-like contrast by the age of 1;9, whereas the fourth child had still not acquired this by 2;3. On the other hand, this child was producing a significant VOT contrast between adult voiced and voiceless stops at the alveolar and velar places of articulation, yet nearly all tokens fell within the short lag range, so that the contrast he was making is probably not perceptible to adults.

Finally, the data are discussed in relation to various theories of phonological development.

Part II: Categorical perception in infants

Morse, Philip A. 1977. "Infant speech perception: origins, processes, and alpha centauri." In Minifie, F. & L. Lloyd (eds.) Communicative and Cognitive Abilities - Early Behavioral Assessment. Baltimore: University Park Press. In press.

This comprehensive summary of research on infant speech perception, especially since 1973, serves as an introduction for the non-specialist as well as providing an extensive list of references. Detailed discussion is included both about theoretical issues and about the various advantages and limits of research paradigms that have been used to determine the nature and extent of the infant's ability to discriminate among speech sounds.

Special emphasis is placed on the distinction between auditory and phonetic, or categorical, discrimination. When infants' responses to two stimuli differ to a statistically significant degree, it is concluded that they are capable of discriminating between them, at least auditorily; conversely, if their responses to two stimuli do not differ significantly, then it is concluded that they do not discriminate between the two. Before it is concluded, however, that infants exhibit categorical, i.e. phonetic, discrimination between two given stimuli, they must not only discriminate reliably (i.e. significantly) between them, but this result must also differ significantly from a result involving another pair of stimuli where reliable discrimination is not exhibited. These seem to be the criteria which the author employs for judging whether certain discriminations that infants make are merely auditory, or whether, in addition, phonetic discrimination, i.e. categorical perception, is involved.

Morse surveys the foundations of infant speech discrimination: the basic of speech production and perception, and the current state of knowledge about infants' abilities for both auditory and phonetic perception. In relation to the phylogenetic origins of speech sound discrimination, the author examines research literature on speech discrimination in rhesus monkeys and chinchillas, arriving at the tentative suggestion that the auditory system of both human and non-human mammals may be psychophysically sensitive to voice onset time (VOT) differences in the region between +10 and +30 ms. after plosive release, precisely where a phonemic boundary occurs for many languages. In addition, Morse reviews literature on the neurophysiological bases for speech sound discrimination, specifically studies on speech adaptation and the hypothesis about the presence of auditory feature analyzers.

Finally, the studies on infant categorical perception are placed within the much larger framework of the task which the infant must accomplish in acquiring the mother tongue, including not only the neces-

sity for perceiving phonetic differences, such as that between [p] and [b], but also the more cognitive task of abstracting a single phonetic category for sounds like [p] which are signalled by different acoustic cues in different phonetic environments.

Kuhl, Patricia K. 1977. "Perceptual predispositions for the acquisition of speech-sound categories: a comparison of human infants and animals." In Minifie, F. & L. Lloyd (eds.) Communicative and Cognitive Abilities - Early Behavioral Assessment. Baltimore: University Park Press. In press.

The basic issue addressed in this paper is whether human language and the capacity of human infants to acquire language is species-specific, or whether nonhuman animals are capable of linguistic behaviors as well. Discussion of this question focuses primarily on categorical perception and the perception of constancy by both human infants and animals. With regard to categorical perception, attention centers on the ability to discriminate initial stops with different voice onset time (VOT) values.

The author reviews the available literature on infant speech perception, categorical perception by adults of non-speech stimuli, and speech perception in animals, principally rhesus monkeys and chinchillas.

Results of the experiments with animals appear to indicate that they discriminate among stop categories in much the same way as human adults and infants, i.e. they show evidence for the ability to form phonetic categories.

In this connection, Kuhl draws an analogy between articulatory gestures and acoustic dimensions on the one hand, and acoustic dimensions and perceptual, or psychoacoustic, attributes on the other hand. Different articulatory maneuvers can produce speech signals with roughly the same acoustic properties, and, similarly, changes can be made in the acoustic properties of a given signal without affecting how that signal is perceived, until the change reaches a "threshold" at which point the signal is abruptly perceived as different.

Although data on infant speech perception have been taken to show that infants process speech sounds in a "linguistic mode," Kuhl makes the point in her discussion that there really is no definition of the term "linguistic mode," and she proposes instead that the ability for infants and animals to discriminate categorically among speech sounds is a reflection of the psychoacoustic properties of the mammalian auditory system, which predisposes both humans and animals to perceive both speech and non-speech sounds in a categorical way.

Eimas, Peter D., Einar R. Siqueland, Peter Jusczyk, & James Vigorito. 1971. "Speech perception in infants." Science 171:303-306.

This is a classic study on the discrimination of speech sounds in infants, the results of which have been taken as evidence for the ability of infants to perceive speech sounds categorically.

Investigators made use of the high-amplitude, non-nutritive sucking paradigm for determining whether or not infants from an American English background could discriminate among synthetic stops with the following six voice onset time (VOT) values: -20, 0, +20, +40, +60, and +80 ms. Subjects were 1 and 4 months old, with 18 infants in each age group.

Results are very similar for subjects from both age levels and indicate that infants discriminate between two stops if they occur at points along the VOT continuum which are separated by the English phoneme boundary, i.e. between +20 and +40 ms. On the other hand, discrimination was not exhibited between stops belonging to the same English phoneme category. The authors conclude that infants are capable of perceiving speech in a manner approximating that of adults: discrimination between sounds coincides with the boundaries separating phonemic categories.

Eilers, Rebecca E. & Fred D. Minifie. 1975. "Fricative discrimination in early infancy." Journal of Speech and Hearing Research 18:158-167.

Mindful of the infant perception literature dealing with stop consonants, the authors conducted experiments to test infants' perception of fricatives, which they suggest may be perceived in a manner different from that for perceiving stops.

Eighty-four infants between 4 and 17 weeks of age were selected as subjects for the study, of which approximately 60% completed the experiment. The experimenters presented taped samples of natural speech uttered by an adult male speaker to the infants, and used the high-amplitude sucking paradigm (i.e. pressure recordings of non-nutritive sucking by the infants during auditorily-presented stimuli) as an indication of response to the sounds. The three fricative phoneme contrasts studied were /sa/ vs. /va/, /sa/ vs. /ʃa/, and /sa/ vs. /za/. The two items in each contrast set were played for the experimental group subjects in both possible orders of presentation; a control group listened to repetitions of one syllable only from each set, with no switch of stimuli after habituation.

Statistical analysis of the results showed an increase in mean sucking rates after the stimuli were switched for the /sa/ vs. /va/ and /sa/ vs. /ʃa/ test groups, but no difference in mean sucking rate was observed

between the experimental and control groups for the /sa/ vs. /za/ pair (i.e. the test subjects appeared not to respond to the contrast). This lack of response to the /sa, za/ contrast is not concrete evidence that the infants did not recognize the contrast; it may be the case that the infants did not find the contrast salient enough to have a reinforcing effect. If it is true, however, that infants did not recognize the voicing distinction, then the ability to perceive phoneme contrasts based solely on voice onset time (VOT) (which is named as the primary difference between /sa/ and /za/) is not an ability that infants of this age can be claimed to have.

The authors suggest that the apparent VOT discrimination abilities reported for infants for stop consonants in the infant perception literature (notably Eimas et al. 1971) are perhaps the misinterpretation of results due, instead, to the presence or absence of an F1 transition.

Eimas, Peter D., Einar R. Siqueland, Peter Jusczyk, & James Vigorito. 1971. "Speech perception in infants." Science 171:303-306.

Lasky, Robert E., Ann Syrdal-Lasky, & Robert E. Klein. 1975. "VOT discrimination by four-to-six-and-a-half-month old infants from Spanish environments." Journal of Experimental Child Psychology 20: 215-225.

This study, like those of Streeter (1976) and Streeter & Landauer (1976), approaches the problem of the role of experience in the development of speech perception, specifically of voice onset time (VOT) in initial stops. Subjects were 30 infants in Guatemala City, with a mean age of 5 mo., 7.2 days, who had been exposed only to Spanish, a language which distinguishes between long lead and short lag stops.

Discrimination was determined by the habituation and dishabituation of the orienting reflex as indexed by cardiac deceleration, and the subjects were tested for the ability to discriminate between bilabial stops in the following three pairs of synthetic CV stimuli: 1) -60 vs. -20, 2) -20 vs. +20, and 3) +20 vs. +60 ms. Results indicate that the infants discriminate between stops of the first and third pairs but not of the second. It is suggested that infants have the innate ability to perceive three categories of stops, with one boundary lying somewhere between -60 and -20 ms., and the other between +20 and +60 ms. The latter distinction corresponds to the location of the phoneme boundary for English, but neither distinction corresponds to the phoneme boundary for Spanish (as reported by Abramson & Lisker 1970, 1973), indicating that linguistic environment plays very little role in the perception of VOT differences at this age.

(The infant data reported in this study do not accord with those on adult perception, as reported by Williams (1974), who found that the per-

ceptual crossover boundary for monolingual Spanish listeners lies at about -4 ms.)hc

Abramson, Arthur S. & Leigh Lisker. 1970. "Discriminability along the voicing continuum: cross-language tests." In Proc. of the 6th Int. Congress of Phonetic Sciences. Prague: Academia.

Abramson, Arthur S. & Leigh Lisker. 1973. "Voice timing perception in Spanish word-initial stops." Journal of Phonetics 1:1-18.

Streeter, Lynn. 1976. "Language perception of 2-month-old infants shows effects of both innate mechanisms and experience." Nature 259: 39-41.

Streeter, L.A. & T.K. Landauer. 1976. "Effects of learning English as a second language on the acquisition of a new phonemic contrast." Journal of the Acoustical Society of America 59:448-451.

Williams, L. 1974. "Speech perception and production as a function of exposure to a second language." Ph. D. thesis, Harvard University.

Williams, Lee. 1977. "The voicing contrast in Spanish." Journal of Phonetics 5:169-184.

Streeter, Lynn. 1976. "Language perception of 2-month-old infants shows effects of both innate mechanisms and experience." Nature 259: 39-41.

This study concerns the hypothesis that discrimination between stops differing in VOT value is accomplished by innate perceptual mechanisms predisposed to the perception of speech. There is evidence (Eimas et al. 1971) that American infants only one month of age can discriminate short lag vs. long lag stops, and to test whether or not this ability is dependent upon prior linguistic exposure, the author investigates the discrimination abilities of infants exposed only to Kikuyu, a language spoken in Kenya which, unlike English, makes use of a distinction between long lead and short lag stops.

Subjects were 36 infants with a mean age of 63 days from monolingual Kikuyu homes. Discrimination data were collected using the non-nutritive sucking paradigm, and the synthetic stimuli were six CV syllables with differing VOT values. The infants were tested in three experimental conditions with the following VOT contrasts: 1) -30 vs. 0, 2) +10 vs. +40, and 3) +50 vs. +80 ms. There was also a control condition in which the VOT values of the two stops were identical.

Results indicate that the infants can discriminate between stops of

-30 and 0 ms. and between stops of +10 and +40 ms. No adult data are given, but it was reported that monolingual Kikuyu adults can make the same discriminations; thus, the author concludes that the perception of the distinction between long lead and short lag stops is dependent upon prior linguistic exposure, whereas the contrast between short and long lag stops has psychoacoustic properties which render it more naturally discriminable.

Eimas, Peter D., Einar R. Siqueland, Peter Jusczyk, & James Vigorito. 1971. "Speech perception in infants." Science 171:303-306.

ADDENDUM (to the list of references provided in the Introduction)

Lisker, Leigh. 1976. "On learning a new contrast." In Jazayery, M.A., E.C. Polome, & W. Winter (eds.) Linguistic and Literary Studies in Honor of Archibald Hill. Lisse, Belgium: Peter de Ridder Press. Vol. 1. Pp. 201-216.

Yeni-Komshian, Grace H., Alfonso Caramazza, & Malcolm S. Preston. 1977. "A study of voicing in Lebanese Arabic." Journal of Phonetics 5: 35-48.